DOCUMENT RESUME

ED 173 142 SE 027 976

AUTHOR Chambers, Donald L.; Dowling, Kenneth W.
TITLE Changing to the Metric System.
INSTITUTION Wisconsin State Dept. of Public Instruction, Madison.
SPONS AGENCY Office of Education (DHEW), Washington, D.C.
REPORT NO WSDPI-Bull-8177
PUB DATE [78]
NOTE 37p.; Contains occasional light and broken type

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Bibliographies; *Curriculum; Educational Change; Elementary Secondary Education; *Mathematics Education; *Mathematics Instruction; *Measurement; *Metric System; *Objectives; Resource Materials

ABSTRACT

This report examines educational aspects of the conversion to the metric system of measurement in the United States. Statements of positions on metrication and basic mathematical skills are given from various groups. Base units, symbols, prefixes, and style of the metric system are outlined. Guidelines for teaching metric concepts are given, including organization of behavioral objectives by grades and topics and student behavioral objectives. Resources for support of metric education, such as the MeasureMetric Instructional Television Series and Metric Week, are reviewed. A bibliography of printed resources on metric education is given. (MP)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

SE

COPY AVAILABLE

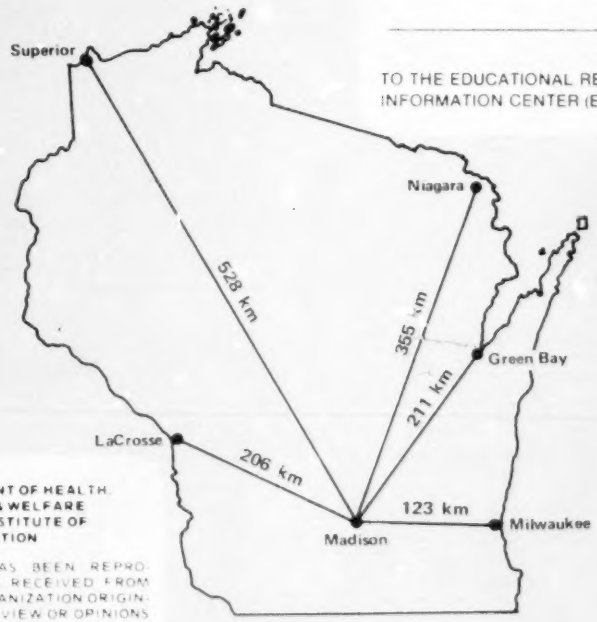
ED173142

CHANGING TO THE METRIC SYSTEM

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

L. Harmatuck

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."



U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

SE 027 976

Wisconsin Department of Public Instruction
Barbara Thompson, Ph.D., State Superintendent

CHANGING TO THE METRIC SYSTEM

PREPARED BY:

DONALD L. CHAMBERS, SUPERVISOR OF MATHEMATICS
WISCONSIN DEPARTMENT OF PUBLIC INSTRUCTION

KENNETH W. DOWLING, SUPERVISOR OF SCIENCE
WISCONSIN DEPARTMENT OF PUBLIC INSTRUCTION

PUBLISHED BY:

WISCONSIN DEPARTMENT OF PUBLIC INSTRUCTION

ARNOLD M. CHANDLER, DIRECTOR
BUREAU FOR PROGRAM DEVELOPMENT

ROBERT C. VAN RAALTE, ASSISTANT SUPERINTENDENT
INSTRUCTIONAL SERVICES DIVISION

This project was supported in part by funds appropriated under ESEA, Title IV (P.L. 93-380). However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S. Office of Education and no official endorsement by the U.S. Office of Education should be inferred.

Bulletin No. 8177

Table of Contents

INTRODUCTION 1

The Wisconsin Department of Public Instruction Position on Metrication 5

The Wisconsin Vocational, Technical & Adult Education Board Position on Metrication 5

The National Council of Supervisors of Mathematics Position on Basic Mathematical Skills 6

THE METRIC SYSTEM 7

Base Units 7

Symbols 8

Prefixes 8

Style 9

GUIDELINES FOR TEACHING METRIC CONCEPTS 1

Organization of Behavioral Objectives By Grades and Topics 15

Student Behavioral Objectives 16

SUPPORT FOR METRIC EDUCATION

MeasureMetric Instructional Television Series 27

Metric Week 28

BIBLIOGRAPHY OF PRINTED RESOURCES ON METRIC EDUCATION 34

CHANGING TO THE METRIC SYSTEM

INTRODUCTION

Conversion to the metric system of measurement in the United States is no longer a matter of future planning. It is happening now. In December of 1975, the President commented while signing the Metric Conversion Act:

> The truth is that our continued use of the English system of measurement was making us an island in a metric sea. In 1965, Great Britian renounced its old system of measurement in favor of metric. It was followed by the Commonwealth countries. Today, more than 90 percent of the world's people uses metric measurement in their everyday lives.

In that statement the President acknowledged that the U.S. has little choice if it is to communicate measurements to other countries, to participate in world trade and to be efficient in measurement practices at home. The United States was one of 17 countries to sign the Treaty of the Meter in 1875 but use of the system was never implemented. England and Canada, among the last nations to change, were well into the process of implementation before leaders in the United States decided to give up the obsolete English system of measurement.

The Metric Conversion Act of 1975 states:

> It it therefore declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

Although the Act allows for voluntary conversion, there can be no doubt that the pressing need for a better measurement system will bring rapid change. Many United States industries that trade outside national boundaries had partially or totally converted before 1975. Now the internal use of metric units, even in the most common measurements, is increasing. It is no longer uncommon to see road signs that give distances between cities in kilometers. Speed limits will be posted in metric units in the future. The National Weather Service is reporting temperatures in both systems and intends to phase out the English system entirely as soon as public understanding and acceptance are assured.

The national advantages of adopting the International System of Units (SI)[1] are obvious in a world situation where rapid communication and exchange of goods are increasingly important. However, there are also advantages for the individual. The International System of Units is structured on multiples of ten to simplify measurement as well as conversion within the metric system. In addition, units of a few basic quantities are used to derive all other measurable characteristics of physical phenomena. These attributes of the metric system lead in turn to simplifying the learning of the concepts and processes related to measurement.

---

[1]The International System of Units (Le Système International d'Unités) is an extended and modernized version of the metric system that originated in France in the eighteenth century.

No one can deny that conversion to the International System of Units is creating numerous problems. Obviously, as the system is implemented, it is necessary for the entire technology of the United States to undergo extensive changes. New standards for production are being established to conform to the rest of the metric world. Industry is being retooled, measurement devices are being recalibrated, controlling codes are being readjusted, and new procedures for conducting the trades are being established. The cost of these changes will be great, but the methods for causing change are fairly clearcut. The greatest difficulty is changing people who think and act using a customary system of measures that is inbedded in a thousand years of past Anglo-Saxon culture. This system has become an integral part of the general behavior of all United States citizens and now a new language of measurement is being imposed upon them. They are not only being asked to translate from one language to another, but to actually become bilingual in measurement and within a few years to think entirely in the new language with no further dependence on the comfortable but obsolete system.

Some of the individual changes involve problems of motivation. People must accept the need for change and, in fact, desire the break from tradition. This requires a general affective value change that cannot be expected to come automatically. In addition, there are cognitive problems that must be solved. Effective individual use of the International System requires understanding of the mathematical concepts of exponential notation using powers of ten, and competence in use of decimal numeration. Also essential are the fundamental physical concepts of linear and angular dimensions, and understanding of the basic quantities that are used to

derive all other quantities in the metric system. Understanding the basis of measurement using relative comparisons and standardized units is also required. Perhaps most important, an intuitive feeling for the relationship between units and the magnitude of the most commonly used units in the new system must become part of the individuals' measurement understanding.

Temporary problems exist in the transitional period while the various sectors of society are making the conversion from the old system to the new. During this period it is necessary to continually translate from one system to the other until general familiarity makes it no longer necessary to compare the two. For some time it will be necessary to provide interchangeable items described in both systems and while new size standards are applied to production, supplies of replacement items manufactured according to the old standards must be maintained. Regulation during this period is essential to prevent perpetuation of the old system and to protect the individual from unfair practices involving a system of weights and measures that he has not yet learned to understand.

It is known that a concentrated effort is required to move people toward the unfamiliar system of metric measurement. Since many of the problems associated with the change are educational, it is reasonable to expect that much of the effort must come from the schools. But to be realistic, it must be realized that the educational community also has to re-educate within its ranks before it can become an effective force in implementing an inevitable change.

THE WISCONSIN DEPARTMENT OF PUBLIC INSTRUCTION POSITION ON METRICATION

The Wisconsin Department of Public Instruction has issued the following position statement:

> The official conversion to metric measurement in the United States is inevitable. Moreover, the problems of changing to a new system of measurement have strong implications for public education. Therefore, the Wisconsin Department of Public Instruction strongly supports activities in the schools that will contribute to an efficient and convenient transition. This support applies to changes in the use of units as they apply to the regular curriculum in all instructional areas and to measurement within school processes as well as to a new emphasis on direct teaching of the concepts and abilities that are necessary for individuals to use the International System of Units. Because the change will require that individuals be able to think and act using only metric units there should not be an emphasis on conversion or translation from one system of units to the other. Instead, school administrators and teaching faculty members should prepare their students for a time when there will be a complete dependence on the metric system in all aspects of measurement with only transitional and historical reference to the English system.
>
> The Metric Conversion Act of 1975 has mandated the change to the metric system. Although a specific timetable for change has not been established, it is obvious that the public schools cannot wait to act. Familiarity and competence with metric measurement now will make accpetance of change easier as the requirements of the national decision go into effect.

THE WISCONSIN VOCATIONAL, TECHNICAL AND ADULT EDUCATION BOARD POSITION ON METRICATION

It is the policy of the Wisconsin Board of Vocational, Technical and Adult Education that:

1. the metric system become the principle system of measures in the curriculum for all vocational, technical and adult education classes in the state;

2. metric system usage be implemented in all levels of classes, adult basic education through the liberal arts including adult and continuing education classes, with the expressed intention of ensuring that programs of instruction become predominantly metric by September 1980;

3. metrication be applicable to all areas of the curriculum and that all measured quantities, wherever appropriate, be stated in metric units;

4. the units and symbols of the metric system taught in the schools conform to those of the International System of Units, known commonly as SI;

5. metrication (process of changing to the SI system of measurement) be accepted as an opportunity to reassess pedagogical approaches toward the topic of measurement as a whole (toward a core of knowledge); and that in addition students be provided with opportunities to acquire practical and experiential knowledge of metric units through activities that involve comparing, estimating, measuring and related problem-solving;

6. metric changes in the curriculum be coordinated with corresponding changes in industry and commerce;

7. metrication at the State Board and VTAE districts be carried out on a pre-planned and gradual basis, with due consideration being given to the attrition, modification and replacement of materials, as well as to the availability of technically correct learning materials.

THE NATIONAL COUNCIL OF SUPERVISORS OF MATHEMATICS POSITION ON BASIC MATHEMATICAL SKILLS

The National Council of Supervisors of Mathematics (NCSM), during the 1976 Annual Meeting in Atlanta, Georgia, met in a special session to discuss the Euclid Conference Report.[2] As a result of action taken

[2]A conference sponsored by the National Institute of Education on "Basic Mathematics Skills and Learning", held in Euclid, Ohio in October 1975.

at that meeting, a Task Force on Basic Mathematical Skills was selected and a Position Paper on Basic Mathematical Skills was prepared.

That position was subsequently adopted by the NCSM at its 1977 Annual Meeting, by the Association of State Supervisors of Mathematics, by the National Council of Teachers of Mathematics and by the Wisconsin Mathematics Council.

The position identifies ten interrelated and overlapping skill areas: 1) problem solving, 2) applying mathematics to everyday situations, 3) alertness to the reasonableness of results, 4) estimation and approximation, 5) appropriate computational skills, 6) geometry, 7) measurement, 8) reading, interpreting and constructing tables, charts and graphs, 9) using mathematics to predict, and 10) computer literacy. About measurement, the statement says:

> As a minimum skill, students should be able to measure distance, weight, time, capacity and temperature. Measurement of angles and calculations of simple areas and volumes are also essential. Students should be able to perform measurement in both metric and customary systems using the appropriate tools.

The position also observes that:

> ...as society changes, our ideas about which skills are basic also change. For example, today our students should learn to measure in both the customary and metric systems, but in the future, the significance of the customary system will be mostly historical."

THE METRIC SYSTEM

Base Units

Four metric units are commonly used in everyday living and in the K-12 curriculum. The meter is used to measure length. A meter is about

the width of a twin bed. A liter is used to measure capacity and is just about a quart. The weight, or mass, of an object is measured in grams. The weight of a nickel is nearly 5 grams. Temperatures are measured in degrees Celsius. Water freezes at zero degrees Celsius and boils at one hundred degrees Celsius. Normal room temperature is twenty degrees Celsius and normal body temperature is thirty-seven degrees Celsius.

Symbols

Each of the base units can be represented by a symbol. These symbols are not abbreviations and therefore are not followed by periods. The symbols are:

Unit Name	Unit Symbol
meter	m
liter	L
gram	g
degree Celsius	^{o}C

Prefixes

A system of prefixes has been developed for measurements which are larger or smaller than the base units. The same prefixes can be applied to meters, liters, and grams, but no prefixes are applied to degrees Celsius.

The prefix for 1000 is "kilo". One could speak of 1000 meters or of 1 kilometer. A kilometer is the length of three and one-half football fields. Similarly, 1000 grams is 1 kilogram. A kilogram is the weight of a liter of water. Because the kilogram is often a more suitable magnitude for measuring weight it is usually the prefered unit.

Other commonly used prefixes are centi and milli. One centimeter is one hundredth of a meter and is about the width of a paper clip. One millimeter is one thousandth of a meter (one tenth of a centimeter). A dime is one millimeter thick. Other commonly used metric prefixes and their symbols are:

SI UNIT PREFIXES

Prefix	*Symbol*	*Factor*	*Meaning*
mega-	M	1 000 000	one million times a-
kilo-	k	1 000	one thousand times a-
hecto-	h	100	one hundred times a-
deka-	da	10	ten times a-
meter		1	(base unit)
liter		1	(base unit)
gram		1	(base unit)
deci-	d	0.1	one tenth of a-
centi-	c	0.01	one hundredth of a-
milli-	m	0.001	one thousandth of a-
micro-	μ	0.000 001	one millionth of a-

Italicized prefixes are those most commonly used.

Style

The spelling of meter and liter in the English language has not been standarized. "Meter" and "metre" (as well as "liter" and "litre") are both correct. People will need to recognize both spellings as both are likely to continue in use.

The names of metric units always begin with a lower-case letter, except at the beginning of a sentence. The only exception is the degree Celsius, named for Anders Celsius, a Swedish astronomer who invented the Celsius thermometer in 1742.

The symbols of metric units which are named after persons are upper-case letters, all others are lower-case letters. The symbol for degree Celsius is ^{o}C. An exception is the symbol for liter, which was recently changed from ℓ to L, primarily due to the fact that many typewriters use the same key for the numeral one and the lower case ℓ.

The names of metric prefixes always begin with a small letter, except at the beginning of a sentence.

The name of a unit is made plural by adding "s": one kilogram; seven kilograms. The symbol of a unit remains the same for both singular and plural: 1 kg; 7 kg.

In order to provide appropriate emphasis to both prefixes and base units, a prefix is never used alone. We do not refer to a kilogram of flour as a kilo of flour. In pronunciation, the accent is always on the first syllable of the prefix. Kil-ometer is correct; ki-lom-eter is incorrect.

For values less than 1, a decimal form should be used. A zero should precede the decimal point. 0.25 mL is correct; 1/4 mL is incorrect.

A space should separate the numeral from the symbol. 20 mm and 43 ^{o}C are correct; 20mm and 43^{o}C are incorrect.

The period "." or raised dot "•" may be used as a decimal point. Some European nations use the comma as a decimal point. This can lead to

confusion since other nations use the comma to mark off groups of three digits for easy reading. The international standard is to avoid the use of the comma in either case. A space can be used to mark off groups of three digits on either side of the decimal point: 1 517 462 • 374 61.

The mixing of units should be avoided. 134 cm or 1.34 m is correct; 1 m 34 cm is incorrect.

Exponents should be used with symbols to indicate areas and volumes. 2 cubic centimeters and 2 cm^3 are correct; 2 cc is incorrect. Young children may use "cu cm," "cu dm," and "cu m" until ready for the exponential forms cm^3, dm^3, and m^3.

Units are sometimes combined to represent quantities such as speed which involves both distance (length) and time. The speed unit is meters per second. Using symbols, speed is indicated by m/s where the slash indicates division of units.

GUIDELINES FOR TEACHING METRIC CONCEPTS

Metric education must be integrated with the regular curriculum. It is interdisciplinary and involves competence in the process of measuring as well as using new knowledge. Although that makes metric education seem complex, it really does not have to be. Educators only need a system for planning.

Sometime ago a committee representing the Wisconsin Mathematics Council, the Wisconsin Society of Science Teachers and the Wisconsin Department of Public Instruction met to consider developing a set of guidelines for metric education that could serve as the basis for planning

metric education at the local level. In the process of establishing the guidelines several observations about learning, the nature of measurement and the metric system were set down as criteria for further development. Among these observations were:

- Children cannot learn or use skills or concepts that are beyond their level of intellectual maturity.
- Measurement is a process that is developed through actual practice and experience.
- Metric measurement is only the application of special metric units to the fundamental measurement process.
- The process of measurement requires mastery of skills and concepts that are sequential.
- The use of arbitrary units should precede use of standard units in teaching the measurement process.
- Measurement depends upon a few basic quantities and a variety of other quantities that are derived from those basic quantities.
- The initial concepts of metric education are appropri tely introduced in kindergarten and the essential concepts and skills can be acquired by the end of grade 8.

These generalized observations were used by the Committee to prepare the "Guidelines for Teaching Metric Concepts" which were first published in the Summer, 1975, issue of the Wisconsin Journal of Public Instruction. Since then the Guidelines have been distributed as a reprint of the original article. Those original guidelines have been slightly revised for inclusion in this bulletin.

Use of the Guidelines requires that teachers and other curriculum planners have developed their own competence in metric measurement. In many areas special assistance and inservice training will be necessary. Such teacher improvement programs can often be arranged through the University of Wisconsin System or through the Department of Public Instruction.

The chart on the following page is an array of objectives for metric education by grade level and by topic. Each objective's location is identified by a code, for example 3-W-2, identifies the third grade level, the measurement of weight and the second concept for that grade. Following the chart the actual objectives are listed by topic with the corresponding code reference. As can be seen, the topics are sequenced according to difficulty so that in the early grades the emphasis is on length, capacity and weight. Later, more complex units are introduced. In all cases the concept or skill should be introduced at a given grade level and then used continually from that time on. This means that although all of the identified objectives might be attained by grade 8 (or later) the use of all skills and concepts should continue throughout formal education as competence continues to improve. It is also important to realize that only topics related to basic units for length, weight (mass), time and temperature have been introduced in these guidelines. This is followed sequentially by examples of derived units; density, force, velocity, and acceleration. Students who continue in science and other fields will eventually have to become familiar with basic units for electric current (ampere). luminous intensity (candela), amount of substance (mole) and angle (radian).

	To Be Accomplished By The End of Grade:								
	K	1	2	3	4	5	6	7	8
Metric Length	K-L-1 K-L-2	1-L-1	2-L-1 2-L-2	3-L-1 thru 3-L-4	4-L-1 thru 4-L-8	5-L-1 thru 5-L-3	6-L-1 thru 6-L-5	*	8-L-1 8-L-2
Metric Weight	K-W-1	1-W-1	2-W-1 2-W-2	3-W-1 thru 3-W-3	4-W-1 thru 4-W-4	5-W-1 thru 5-W-3	6-W-1 thru 6-W-6	7-W-1 7-W-2	*
Metric Capacity		1-C-1 1-C-2	2-C-1 2-C-2	3-C-1 3-C-2	4-C-1 thru 4-C-7	5-C-1 thru 5-C-3	6-C-1 thru 6-C-3	*	*
Metric Area			2-A-1 thru 2-A-3	*	4-A-1 thru 4-A-3	5-A-1 thru 5-A-7	6-A-1 thru 6-A-3	7-A-1 7-A-2	8-A-1 thru 8-A-3
Metric Volume			2-V-1 thru 2-V-3	3-V-1 3-V-2	*	5-V-1	6-V-1 thru 6-V-12	7-V-1 thru 7-V-3	8-V-1 8-V-2
Metric Temperature			2-T-1	3-T-1 3-T-2	4-T-1 thru 4-T-3	5-T-1 thru 5-T-3	6-T-1 6-T-2	*	8-T-1 thru 8-T-4
Metric Density								7-D-1	8-D-1 thru 8-D-4
Metric Force							6-F-1	7-F-1 thru 7-F-3	8-F-1 thru 8-F-3
Metric Velocity							6-v-1 6-v-2	7-v-1 thru 7-v-4	8-v-1 thru 8-v-3
Metric Acceleration									8-a-1 thru 8-a-5

*Concepts and skills introduced in previous grades should be reviewed and expanded.

STUDENT BEHAVIORAL OBJECTIVES

LENGTH

The students will:

K-L-1 Demonstrate an understanding that the length of a given object does not change regardless of the location or position of the object.

K-L-2 Compare lengths using terms such as "longer than," "shorter than," or "same as."

1-L-1 Use arbitrary (non-standard) units to measure length. For example, measure the length of a chalk tray in pencils, string segments, paces, finger spans, etc.

2-L-1 Use a ruler calibrated in centimeters (no subdivision) to measure length.[3]

2-L-2 Read length measures to the nearest centimeter.

3-L-1 Read and record a given length in centimeters using a numeral with the symbol cm. For example, the length of a paper clip is 3 cm.

3-L-2 Use a meter stick (or tape) to measure length to the nearest meter and to the nearest centimeter.

3-L-3 Record a given length in meters to the nearest meter using a numeral with the symbol m. For example the length of a room is 8 m.

3-L-4 Show that there are 100 centimeters in 1 meter.

4-L-1 Select standard units over arbitrary units to communicate lengths.

4-L-2 Use the kilometer to describe long distances. For example, the distance between Madison and Milwaukee is 123 km.

4-L-3 Use a measuring device calibrated in millimeters.

---

[3]The decimeter can be introduced as a unit for informal measuring at this stage of development, but this practice is not considered necessary to this sequence of metric objectives.

4-L-4 Read measures less than 1 meter to the nearest millimeter.

4-L-5 Record a given length in millimeters using a numeral with the symbol mm. For example, a piece of paper is 215 mm wide.[4]

4-L-6 Show that there are 1000 mm in 1 m.

4-L-7 Show that there are 10 decimeters in one meter.

4-L-8 Convert measures given in meters to measures given in centimeters or decimeters.

5-L-1 Convert measures given in kilometers to measures in meters; convert measures given in meters or centimeters to measures in millimeters.

5-L-2 Round off measures given in centimeters to the nearest meter.

5-L-3 Measure perimeters of physical objects using metric units.[5]

6-L-1 Convert measures given in millimeters to measures in centimeters; convert measures given in centimeters or decimeters to measures in meters; convert measures given in meters to measures in kilometers.

6-L-2 Round off measures given in millimeters to the nearest centimeter.

6-L-3 Order measures given in millimeters, centimeters and meters.

6-L-4 Use a surveyor's tape and a trundle wheel to measure distances in metric units.

6-L-5 Compute perimeters of polygons given the measures of the sides in metric units.

8-L-1 Compute circumferences of circles given the measures of the radii in metric units.

8-L-2 Estimate lengths with a reasonable degree of accuracy using centimeters or meters.

---

[4] The metric prefixes "deka" and "hecto" are not commonly used and thus do not appear in this sequence of objectives.

[5] At each grade level it is expected that students will actually measure lengths using appropriate instruments.

WEIGHT

The student will:

K-W-1 Demonstrate having attained a concept of measurable quantities by asking questions such as "how much?" "how far?" and "how old?"

1-W-1 Demonstrate an intuitive feeling for weight as a measure of an amount of matter.

2-W-1 Indicate that the amount of matter in an object (such as a lump of clay) remains the same when the shape is changed.

2-W-2 Indicate that the amount of matter in an object will remain the same when it is broken into parts or when the parts are put back together to make the whole.

3-W-1 Use weight (mass) as an indication of the amount of matter in a given object.

3-W-2 Compare or classify objects by heft.

3-W-3 Use an equal arm balance to compare weights.

4-W-1 Use the terms weight and mass as synonyms.[6]

4-W-2 Use an arbitrary unit to measure and compare weights.

4-W-3 Use the standard units gram and kilogram to measure and describe weights.

4-W-4 Use g as the symbol for gram; use kg as the symbol for kilogram.

5-W-1 Use spring balances, kitchen scales and other devices to determine weights.

5-W-2 Select standard units over arbitrary units to communicate weights.

5-W-3 Convert measures given in kilograms to measures in grams.

---

[6] In these guidelines the term "weight" is used as having the same meaning as the term "mass." Therefore, weight is taken to be different from force due to gravity. This is consistent with the recommendation of the National Bureau of Standards.

6-W-1 Use the milligram to describe weight.

6-W-2 Use the symbol mg for milligram.

6-W-3 Convert measures given in grams to measures in milligrams; convert measures given in grams to measures in kilograms; convert measures given in milligrams to measures in grams.

6-W-4 Indicate that the kilogram is the basic unit of weight in SI

6-W-5 Define the kilogram as the weight of one cubic decimeter (liter) of pure water at 4 ^{o}C; also, the gram as the weight of one cubic centimeter of pure water at 4 ^{o}C.

6-W-6 Choose appropriate multiples of the gram to describe weight.

7-W-1 Estimate the weight of objects in appropriate multiples of the gram to a reasonable degree of accuracy.

7-W-2 Use calibrated weights with an equal arm balance and triple beam balance to determine the weight of a given object.

CAPACITY

The student will:

1-C-1 Show that an amount of liquid or granular substance does not change when it is poured from one container into a container of a different shape.

1-C-2 Compare the amounts of liquid or granular substance in two containers of the same size and shape by using the terms "same amount," "more than," and "less than."

2-C-1 Compare the capacities of various containers by filling the containers with a liquid or granular substance and place the containers in order from largest to smallest.[7]

---

[7]In the classroom, the concept of capacity precedes the concept of volume. In the metric system no distinction is made between liquid and dry capacity measures. Since the liter is defined as being as equal to a cubic decimenter, in the upper grades the terms volume and capacity are often used synonymously.

2-C-2 Determine how many non-standard units (small containers) it will take to fill a given container.

3-C-1 Identify a model of a liter from models that are smaller than 0.5 liter or greater than 1.5 liters.

3-C-2 Determine the capacity of a container to the nearest liter (e.g., use a model liter and a liquid or granular substance to fill a container.

4-C-1 Select standard units over arbitrary units to communicate capacities.

4-C-2 Use the symbol L for liter.

4-C-3 Use a graduated container to determine the measure of an amount of liquid or granular substance to the nearest one hundred milliliters.

4-C-4 Show that there are 1000 milliliters in 1 liter.

4-C-5 Use a graduated container to determine the capacity of a container to the nearest one hundred milliliters.

4-C-6 Use the symbol mL for milliliter.

4-C-7 Compare measures such as 250 mL, 1 L, 3 L, 200 mL, 1200 mL, etc.

5-C-1 Convert measures given in liters to measures in milliliters.

5-C-2 Show that there are 1000 liters in 1 kiloliter.

5-C-3 Convert measures given in kiloliters to measures in liters.

6-C-1 Use a graduated container to determine the measure of an amount of liquid or granular substance to the nearest milliliter.

6-C-2 Use a graduated container to determine the capacity of an arbitrary container to the nearest milliliter.

6-C-3 Convert measures given in milliliters to measures in liters; convert measures given in liters to measures in kiloliters.

AREA

The student will:

2-A-1 Show, given two or more arrangements of a set of uniform square tiles, that the number of squares remains the same regardless of the configuration.

2-A-2 Count the number of squares in a rectangular two-dimensional region where the squares are drawn on the region.

2-A-3 Compare the number of squares in two or more two-dimensional regions using the terms "less than", "greater than", and "same as".

4-A-1 Explain the notion of area.

4-A-2 Determine areas of specified surfaces by covering the surfaces with arbitrary units. Examples of arbitrary units include books, sheets of paper, and other flat objects of the same size and shape.

5-A-1 State the dimensions of a square centimeter as one centimeter by one centimeter.

5-A-2 Determine areas of rectangular regions by covering the surfaces with square centimeters.

5-A-3 Determine approximate areas of non-rectangular regions by covering the surfaces with square centimeters.

5-A-5 Use the symbol cm^2 for square centimeter.[8]

5-A-6 State the dimensions of a square meter as one meter by one meter (or 100 cm by 100 cm.)

5-A-7 Use the symbol m^2 for square meter.[8]

6-A-1 Measure the dimensions and compute the areas of rectangular regions using centimeters or meters using the formula A=l x w.

6-A-2 Compute the areas of rectangular regions given the dimensions in any metric unit of length.

---

[8] Pedagogically, the use of "sq cm" and "sq m" probably will preceed use of the symbol cm^2 and m^2.

6-A-3 Select standard units over arbitrary units to communicate areas.

7-A-1 Compute the areas of common polygons given the required dimensions in metric units.

7-A-2 Compute the surface areas of rectangular solids given the required dimensions in metric units.

8-A-1 Compute the areas of circular regions after measuring the radii in appropriate metric units.

8-A-2 Compute the surface areas of prisms, pyramids, cylinders and cones given the required dimensions in metric units or by measuring dimensions in appropriate metric units.

8-A-3 Compute the area of arbitrary polygonal regions, given the required dimensions in metric units, by partitioning the region into common polygons and summing areas.

VOLUME

The student will:

2-V-1 Show, given 2 three-dimensional figures of the same size and shape constructed from cubes (toy blocks, sugar cubes, etc.), that the number of cubes in each of the two figures remains constant even though the arrangement of the cubes in one or both of the figures may change.

2-V-2 Count the number of cubes in rectangular three-dimensional figures and nonrectangular three-dimensional figures made up of cubes.

2-V-3 Compare the number of cubes in two or more three-dimensional figures using the terms "less than," "greater than," and "same as."

3-V-1 Build, given a set of blocks and a two-dimensional picture of a block structure, a block structure that is like the picture.

3-V-2 Determine the number of blocks in a three-dimensional structure from a two-dimensional picture of the structure.

7-V-3 Determine the volume of a rectangular container by computation using any appropriate metric unit.

8-V-1 Convert volume measures from larger to smaller or smaller to larger metric cubic units.

8-V-2 Estimate the capacity of a container in liters and/or milliliters with reasonable accuracy.

TEMPERATURE

The student will:

2-T-1 Read the room temperature or outdoor temperature to the nearest degree using a Celsius thermometer.

3-T-1 Indicate that temperature is a characteristic of all matter.

3-T-2 Use touch to order temperatures of substances.

4-T-1 Use a Celsius thermometer to measure the temperatures of a variety of places and things.

4-T-2 Use the symbol ^{o}C for degree Celsius.

4-T-3 Estimate environmental temperature in ^{o}C.

5-T-1 Describe the way expansion and contraction of liquids are used to indicate temperature.

5-T-2 Explain how relative temperature scales are developed.

5-T-3 Use a blank thermometer to locate the freezing and boiling points of water as reference points in order to develop the Celsius temperature scale.

6-T-1 Measure change in ^{o}C over time and communicate these measurements using a graph.

6-T-2 Use a blank thermometer and calibrate it in ^{o}C.

8-T-1 Describe kelvin temperature as it relates to the Celsius temperature scale.

8-T-2 Equate the kelvin and the ^{o}C.

8-T-3 Demonstrate volume change of a liquid as a function of temperature.

8-T-4 Graph change in the length of a column of liquid as a function of ^{o}C.

DENSITY

The student will:

7-D-1 Demonstrate that objects with the same weight may have different volumes; also that objects with the same volume may have different weights.

8-D-1 Demonstrate that the ratio of weight to volume is a characteristic quantity of all uniform substances.

8-D-2 Use the term density to mean the ratio of the weight of an object to the volume of the object.

8-D-3 Indicate that the unit for density is kilogram per cubic meter (kg/m^3).

8-D-4 Covert measures given in kg/m^3 to measures in g/cm^3; convert measures given in g/cm^3 to measures in kg/m^3.

FORCE

The student will:

6-F-1 Describe force as a push or pull.

7-F-1 Demonstrate that all objects on earth are attracted to the earth by a force of gravity and that the object attracts the earth with an equal force in the opposite direction.

7-F-2 Indicate the direction of a given force.

7-F-3 Demonstrate that forces are only detected when they cause an effect on matter.

8-F-1 Describe change in motion in terms of applied forces.

8-F-2 Use the newton as the unit of force.[11]

8-F-3 Use the definition of force: 1 newton is the force which when acting on a mass of 1 kilogram causes an acceleration of 1 meter per second per second (m/s^2).

VELOCITY

The student will:

6-v-1 Describe motion in terms of distance traveled and time.

6-v-2 Use the second as the basic metric unit of time.

7-v-1 Use the basic units in mathematical operations to derive units such as m^2, m^3 and m/s (meter per second).

7-v-2 Differentiate between basic metric units and derived metric units.[12]

7-v-3 Determine velocity of a moving object using a metric ruler and stopwatch.

7-v-4 Indicate the direction of a given velocity.

8-v-1 Describe the conditions for uniform velocity.

8-v-2 Graph distance traveled vs time for different uniform velocities.

8-v-3 Convert measures given in m/s to measures in km/hr.

---

[11] The newton is an example of a derived metric unit.

[12] The distinction between basic units and derived units applies to other quantities, but is included in these guidelines only in relationship to velocity. This distinction is critical to advanced measurement.

ACCELERATION

The student will:

8-a-1 Describe acceleration as a change in velocity.

8-a-2 Demonstrate that acceleration is zero when velocity is uniform.

8-a-3 Indicate that positive and negative accelerations are opposite in direction.

8-a-4 Demonstrate that acceleration of an object requires that a force be applied to the object.

8-a-5 Use m/s^2 as the unit for acceleration.

SUPPORT FOR METRIC EDUCATION

The responsibility for metric education falls upon many people in the schools who have a wide range of expertise and experience. It may be expected that many of them are not completely familiar with metric concepts nor skilled in measurement processes. To assist them, a variety of resources have been made available from public sources and professional associations.

MeasureMetric Instructional Television Series

MeasureMetric is an instructional television series for upper elementary or middle school students that uses the metric system in dealing with the process of measurement. The first lesson is an introductory one on the importance of measuring in everyday activities; the remaining eleven lessons are grouped into four clusters; one cluster each on the metric measurement of length, of area, of volume and of mass. Two other measurement topics, temperature and time, are woven into all twelve lessons.

Based on four years of planning and development, the series is designed to help students learn to estimate and measure using the appropriate instruments, and to interpret and communicate measurements. The lessons combine classroom preparation, viewing of the fifteen-minute programs, and student activities.

The MeasureMetric programs have been studied carefully to determine how they coordinate with the Wisconsin Guidelines for Teaching Metric Concepts. The chart on the next page indicates which programs make specific use of given objectives from the Guidelines. Following the chart is a listing of all the objectives that are treated in the series of television programs.

In Wisconsin the MeasureMetric programs have been periodically broadcast on the Instructional Television Network since January of 1977. Future broadcasts will be announced in the Parade of Programs Teachers Handbook published each year by the Wisconsin Educational Communications Board. For up-to-date information write to: E.C.B., 732 North Midvale Boulevard, Madison, WI 53705, or phone (608) 266-0036. Video tape or 16 mm sound films can be rented or purchased. You may also get information on acquiring the MeasureMetric Teachers Guide which includes a large number of learning activities that can be used with the programs.

Metric Week

Each year the week which contains May 10 is designated National Metric Week by the National Council of Teachers of Mathematics. Since 1976 the same week has been observed as Metric Week in Wisconsin and proclaimed as such by the Governor. School personnel may expect that Metric Week will continue to be observed in Wisconsin each year during the week which contains May 10, and are encouraged to plan activities during that week which contribute to the metric awareness of students, faculty, parents and citizens of the community.

MEASUREMETRIC (ITV)/BEHAVIORAL OBJECTIVES CORRELATION*

GRADE LEVEL/TOPIC/OBJECTIVE NUMBER								MEASUREMETRIC PROGRAMS												
								Intro.	Length			Area			Volume			Weight	
								1	2	3	4	5	6	7	8	9	10	11	12
1-L-1								X											
	2-L-1	3-L-4	4-L-6	5-L-3					X										
			4-L-7																
			4-L-2		6-L-1, 6-L-4					X									
				5-L-2	6-L-2		8-L-2				X								
			4-L-8	5-L-1					X	X									
	2-L-2	3-L-1	4-L-3																
		3-L-3	4-L-4						X		X								
			4-L-5																
		3-L-2							X	X	X								
			4-L-1					X	X	X	X								
			4-A-1																
			4-A-2									X							
			4-A-3																
				5-A-2									X						
					6-A-2	7-A-1, 7-A-2								X					
				5-A-3	6-A-1								X	X					
				5-A-5, 5-A-7								X		X					
1-C-1	2-C-2	3-C-2	4-C-3		6-C-1														
			4-C-4		6-C-2										X				
			4-C-5																
				5-V-1	6-V-4														
			4-C-7	5-C-1	6-C-3														
				5-C-2	6-V-10												X		
					6-V-11														
					6-V-12														
			4-C-2, 4-C-6												X		X		
			4-C-1		6-V-1														
					6-V-3														
					6-V-5											X	X		
					6-V-6														
					6-V-8														
					6-V-9														
	2-W-2	3-W-2, 3-W-3				7-D-1												X	
				5-W-1	6-W-1														
				5-W-2	6-W-3														X
				5-W-3	6-W-6														
			4-W-2																
			4-W-3															X	X
			4-W-4																
	2-T-1										X				X				
			4-T-1								X				X		X		
			4-T-2									X			X				

*See reverse side for concept explanation.

Length

1-L-1. Use arbitrary units to measure length.
2-L-1. Use a ruler calibrated in cm to measure length.
2-L-2. Read measures to the nearest cm.
3-L-1. Read and record in centimeters using the cymbol cm.
3-L-2. Use a meter stick to measure to the nearest m and cm.
3-L-3. Record length to the nearest meter using the symbol m.
3-L-4. Show that there are 100 centimeters in 1 meter.
4-L-1. Select standard units to communicate length.
4-L-2. Use the kilometer to describe longer distances.
4-L-3. Use a measuring device calibrated in millimeters.
4-L-4. Record measures less than 1 meter to the nearest millimeter.
4-L-5. Record length in millimeters using the symbol mm.
4-L-6. Show that there are 100 mm in one meter.
4-L-7. Show that there are 10 decimeters in one meter.
4-L-8. Convert measures in meters to measures in cm or dm.
5-L-1. Convert measures in km to m; and m or cm to measures in mm.
5-L-2. Round off measures in mm or cm to the nearest meter.
5-L-3. Measure perimetar of physical objects using metric units.
6-L-1. Convert measures in mm to cm; cm or dm to m; measures in m to km.
6-L-2. Round off measures in mm to the nearest cm.
6-L-4. Use surveyor's tape and trundle wheel to measure distances.
8-L-2. Estimate lengths with close accuracy using centimeters or meters.

Area

4-A-1. Indicate an understanding of the notion of area.
4-A.2. Determine areas by covering the surfaces with arbitrary units.
4-A-3. Determine areas of rectangular surfaces by covering with non-standard units.
5-A-2. Determine areas by covering the surfaces with square centimeters.
5-A-3. Determine approximate areas of non-rectangular regions by covering with square centimeters.
5-A-5. Use the symbol cm^2 for square centimeter.
5-A-7. Use the symbol m^2 for square meter.
6-A-1. Measure and compute area using centimeters or meters.
6-A-2. Compute area of rectangular region given the dimensions.
7-A-1. Compute areas of common polygons given the dimensions.
7-A-2. Compute surface areas of rectangular solids given the dimensions.

Capacity

1-C-1. Show an understanding of conservation of volume.
2-C-2. Determine number of non-standard units to fill a given container.
3-C-2. Determine the capacity of a container to the nearest liter.
4-C-1. Select standard units to communicate capacities.
4-C-2. Use the symbol l for liter.
4-C-3. Use a graduated container to dtermine amount of substance to nearest 100 mm.
4-C-4. Show there are 1,000 milliliters in 1 liter.
4-C-5. Use a graduated container to determine the capacity of a container to the nearest 100 mm.
4-C-6. Use the symbol ml for milliliter.
4-C-7. Compare measures such as 250 ml; 200 ml; 1200 ml, etc.
5-C-1. Convert measures in liters to milliliters.
5-C-2. Show that there are 100 liters in 1 kiloliter.
6-C-1. Use a graduated container to determine amount of substance to nearest milliliter.
6-C-2. Determine capacity to the nearest milliliter.
6-C-3. Convert measures in ml to l, and measures in l to kl.

Volume

5-V-1. Determine how many non-standard units to fill a rectangular box.
6-V-2. Use the cubic centimeter as a standard unit of volume.
6-V-3. Determine the volume of a rectangular container using wood or plastic models of cubic centimeters.
6-V-4. Select standard units to communicate volumes.
6-V-5. Use the symbol cm^3 for cubic centimeter.
6-V-6. Determine volume of rectangular container in cm using V=l x w x h.
6-V-8. Use cm^3 and dm^3 as standard units of volume.
6-V-9. Use symbols m^3 and dm^3 for cubic meter and cubic decimeter.
6-V-10. Show that there are 1000 cm^3 in 1 dm^3.
6-V-11. Indicate that liter is the same as dm^3(1000 cm^3).
6-V-12. Indicate the milliliter is another name for 1 cm^3.

Weight

2-W-2. Indicate amount of matter is the same when broken into parts or when the parts are put back together to make the whole.
3-W-2. Compare or classify objects by heft.
3-W-3. Use an equal arm balance to compare weights.
4-W-2. Use an arbitrary unit to measure and compare weights.
4-W-3. Use the standard units gram and kilogram to describe weights.
4-W-4. Use g for gram; use kg for kilogram.
5-W-1. Use spring balances, kitchen scales, etc., to determine weights.
5-W-2. Select standard units to communicate weights.
5-W-3. Convert measures given in kilograms to measures in grams.
6-W-1. Use the milligram to describe weight.
6-W-2. Use the symbol mg for milligram.
6-W-3. Convert measures in g to mg; g to kg; and measures in mg to g.
6-W-6. Choose appropriate multiples of the gram to describe weight.

Density

7-D-1 Demonstrate objects with same mass may have different volumes; also objects with the same volume may have different masses.

Temperature

2-T-1. Read temperatures to nearest degree using Celsius thermometer.
4-T-1. Measure temperatures of variety of places; use Celsius thermometer.
4-T-2. Use the symbol °C for degree Celsius.

Objectives from Changing to the Metric System; Wisconsin DPI, 1978

The following activities can be used to increase community awareness of Metric Week and its goals:

1. Have a school open house or parent night sponsored by the mathematics department.

2. Devise a metric fair with all metric events, decorations, and prizes. This could be held in conjunction with local businesses, industries, and PTAs, and could include interesting booths, such as height and weight guessing booths; demonstration booths sponsored by Penney's, MacDonald's, Sears, IBM, and the calculator companies, and estimation booths that provide fun for all. Refreshments could be served, and the metric recipes used for making cookies, punch and so forth, could be given out. Door prizes might serve to attract participants if local companies would cooperate.

3. Have a metric field day, with track and field events using metric measures and with various measurement events using estimation and direct and indirect measurement.

4. Create a school or district metric newsletter to be issued regularly.

5. Create programs about the metric system and present them to local civic clubs, PTA and various professional organizations.

6. Write articles for the school newspaper promoting the use of metric measurement.

7. Have the mathematics department plan a metric inservice session for the school faculty.

8. Do a project on metric cooking, working with the home economics department.

9. Have a bake-off and compile a metric cookbook, which will be published by the Mothers Club.

10. Make a map of the school locale using a metric scale.

11. Have students write and perform radio and TV scripts of commercials, playlets and so on, involving metric usage.

12. Create a treasure or scavenger hunt using metric maps or directions with metric items to be found.

13. Put on a "Metric 500" car race using model cars, with solid fuel, CO_2 cartridges or ramps as the source of power.

14. Provide parents with an opportunity to speak to classes on how they use the metric system or how the change to SI will affect their profession.

15. Encourage local corporations to conduct related programs for classes that demonstrate the need for metric measurement.

16. Devise a metric poster contest; seek the sponsorship of PTA, teacher groups, or local service clubs.

17. Plan field trips to places having a large amount of metric materials on display or applying metrication.

18. Arrange to give daily school anouncements of temperature precipitation, barometric pressure and other items in metric units.

19. Have an estimating contest, first in individual classes and then finding the school champion.

20. For metric week, advertise the events through radio, TV and newspapers; invite the media to cover the activities.

21. Obtain a proclamation of a metric week from the school superintendent, the mayor or the governor.

22. Agitate to convert city road signs to metric measures.

23. Promote a radio or TV or newspaper feature story on metric activities.

24. Present an award to the most innovative or future-looking (metric minded) person or segment of your local media, such as the local news or weather reporter.

25. Provide the news media with metric fillers, puzzles and so on.

26. Take Metric Week and its activities to a local shopping center and display, perform or demonstrate ideas by --

    a. putting on a metric-oriented puppet show or play;

    b. using "metric" clothes in a fashion show;

    c. having local industries put up metric displays;

d. coordinating store displays by showing metric items related to their type of business;

e. setting up an activity area where students can perform, demonstrate metrication and involve the shopping public (some "metric fair" types of activities could be used);

f. displaying metric posters, original creations or items collected from magazine ads (display-poster contest winners would make presentations there);

g. displaying the local map in metric scale;

h. persuading the local radio station to broadcast from the metric area, using their booth or trailer;

i. presenting a metric slide/tape show such as that of the National Bureau of Standards or one produced locally by the students; and

j. having a central display of metric items.

27. Have a culminating set of activities for one of the days of your week known as Metric Day.

Bibliography of Printed Resources on Metric Education

American National Metric Council, Metric Guide for Educational Materials, 1625 Massachusetts Avenue, N.W., Washington, DC 20036

Bidwell, James K., Metric Measurement Activity Cards, National Council of Teacher of Mathematics

Bitter, Gary G., and Geer, Charles, Materials for Metric Instruction, National Council of Teachers of Mathematics

Leffin, Walter W., Going Metric: Guidelines for the Mathematics Teacher, Grades K-8, National Council of Teachers of Mathematics, 1906 Association Drive, Reston, Virginia 22091

Lets Measure Metric, A Teachers Introduction to Metric Measurement, Ohio Department of Education, Columbus, Ohio

Metric Education Guide, A Staff Development Program for Texas, Division for Curriculum Development, Texas Education Agency, 201 East 11th Street, Austin, Texas 78701

National Bureau of Standards Special Publication 330, Metric Information Office, National Bureau of Standards, Washington, DC 20234

National Bureau of Standards Special Publication 441, Successful Experiences in Teaching Metric, Metric Information Office, National Bureau of Standards, Washington, DC 20234

Teacher Resource Guide for Metric Education, Michigan Department of Education, Lansing, Michigan

3000-3J92504-78